[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF STANFORD UNIVERSITY]

Saponins and Sapogenins. XIX. The Decarboxylation of Echinocystic Acid

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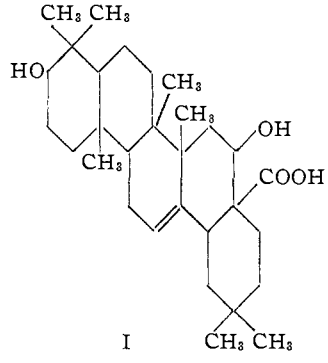
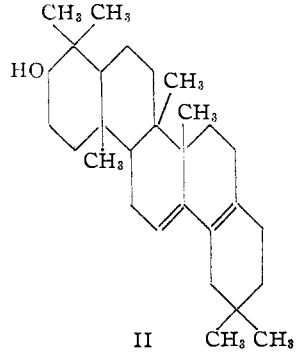
Echinocystic acid is a triterpenoid sapogenin having a secondary hydroxyl group β to a carboxyl group, and another isolated secondary hydroxyl group. A double bond is present, as indicated by the yellow color formed with tetranitro methane, which is either β- or γ- to the carboxyl group since a bromolactone is formed on brominating the diacetate.[1] Recent work has shown that the carbon skeleton of echinocystic acid is closely related to that of oleanolic acid[2] and to quillaic acid,[3] and these facts in the light of our present knowledge indicate that the structure of echinocystic acid is best represented by Formula I.



I



II

We should like to report now that when echinocystic acid is distilled under reduced pressure, the distillate contains a compound corresponding to echinocystic acid which has lost one molecule of water and one molecule of carbon dioxide. It has been shown previously that in the monoacetate obtained by direct esterification of echinocystic acid the hydroxyl group which is not β to the carboxyl group is the one which has been esterified since oxidation of this monoacetate gives rise to a ketoacetate with loss of carbon dioxide.[1] Distillation of this monoacetate under reduced pressure gives rise to a product which after saponification gives the same compound obtained by the distillation of echinocystic acid. Therefore the hydroxyl group which is lost is the one which was β to the carboxyl group. This is what one would expect on the basis of Formula I since loss of carbon dioxide should leave a tertiary hydrogen on the carbon atom adjacent to a hydroxyl group.

On the basis of Formula I one might expect that the product of decarboxylation and dehydration would contain two isolated double bonds. The ultraviolet absorption spectrum,[4] however, shows that not only are two double bonds present but that they form a conjugated system.[5] It might be concluded from this that the relative positions of the double bond and hydroxyl group as given in Formula I are incorrect until one considers that at the elevated temperature of decomposition the double bonds may migrate to a position of conjugation. Actually the absorption spectrum gives added support for Formula I since the maximum of 2410 Å. indicates that the conjugated system is distributed between two rings. This is confirmed by the non-addition of maleic anhydride to the conjugated system and the failure of attempts to bring about catalytic reduction.[6] We accordingly believe that the structure of the new compound, which we have called norechinocystadienol, is best represented by Formula II.

Experimental

Decarboxylation of Echinocystic Acid.—Nine grams of echinocystic acid was distilled into the side arm of a "sausage" flask under a pressure of approximately 10 mm. The flask was heated in a metal bath to 280° until evolution of gas was no longer rapid and then at 300–320° until distillation into the sausage side arm was complete. The solidified glass was melted out of the side arm with a free flame, dissolved in ether and extracted twice with 2 *N* aqueous sodium hydroxide and once with saturated salt solution. The ether solution was filtered to remove suspended sodium

(1) White and Noller, THIS JOURNAL, **61**, 983 (1939).
(2) Todd, Harris and Noller, *ibid.*, **62**, 1624 (1940).
(3) Bilham and Kon, *J. Chem. Soc.*, 1469 (1940).
(4) We are indebted to Dr. R. Norman Jones of Harvard University for the determination of the absorption spectrum.
(5) This is further proof that a double bond is present in echinocystic acid.
(6) Bergmann and Hirschmann, *J. Org. Chem.*, **4**, 40 (1939).

echinocystate, concentrated and cooled. The crystals which separated weighed 2.04 g., m. p. 175–180°. Evaporation of the residue to dryness gave 5.96 g. of residue, which on crystallization from a mixture of 50 cc. of methyl alcohol and 50 cc. of acetone gave 1.0 g., m. p. 175–180°. Further purification by simple crystallization is extremely slow but fairly rapid purification, although rather inefficient, can be attained by dissolving in boiling methyl alcohol, concentrating until a heavy crop of crystals has separated from the boiling solvent and filtering the crystals from the hot mother liquor. After three such crystallizations, the melting point is constant at 192–195°. On drying for analysis at 140° and 20 mm. the compound lost 6.5% in weight compared with the calculated value of 7.2% if it contained a molecule of methyl alcohol of crystallization; $[\alpha]^{24}D$ +81.8° in dioxane.

Anal. Calcd. for $C_{29}H_{46}O$: C, 84.80; H, 11.30. Found: C, 84.98, 85.02; H, 11.27, 11.14.

This material, which is in the form of white needles and only slightly soluble in cold methyl alcohol, slowly becomes yellow on standing in air and is converted into an amorphous resin which is very soluble in methyl alcohol. When kept in an evacuated sealed tube it is perfectly stable.

Conversion to the **benzoate** by means of benzoyl chloride and pyridine in benzene solution gave a product which after three crystallizations from a mixture of acetone and ligroin (60–100°) melted at 231–233° with shrinking at 230°.

Anal. Calcd. for $C_{36}H_{50}O_2$: C, 83.98; H, 9.80. Found: C, 84.32; H, 9.75.

Attempts to reduce norechinocystadienol catalytically or with sodium in butyl alcohol or to condense the acetate with maleic anhydride resulted only in recovery of the original materials.

Decarboxylation of Echinocystic Acid Monoacetate.—Vacuum distillation of 4 g. of the monoacetate of echinocystic acid prepared by direct esterification[1] gave a product which crystallized readily from methyl, ethyl or isopropyl alcohols but from no solvent could a product with a melting point range better than 169–180° be obtained even after thirteen crystallizations. Moreover, the optical rotation did not change appreciably on successive crystallizations. Attempts to remove possible hydroxylated impurities by condensation with succinic anhydride and by acetylation as well as purification by adsorption on activated magnesia were without success.

The recrystallized material finally was saponified and the product recrystallized from hot methyl alcohol to a melting point of 188–193°; $[\alpha]^{23}D$ +82.0 in dioxane. This showed no depression when mixed with norechinocystadienol from echinocystic acid. Conversion to the benzoate gave a product melting at 228–232° which did not depress the melting point of norechinocystadienol benzoate.

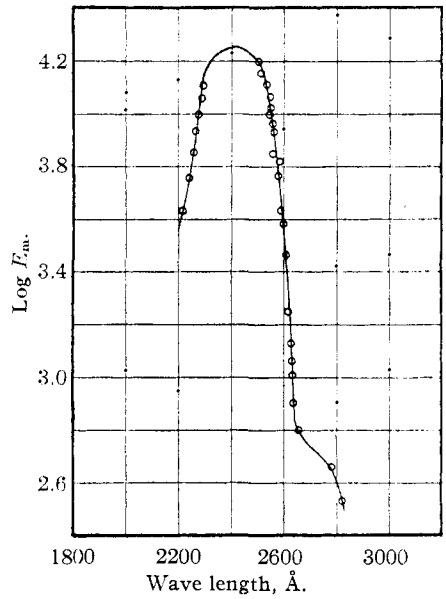


Fig. 1.—Ultraviolet absorption spectrum of norechinocystadienol.

Absorption Spectrum.—The ultraviolet absorption spectrum was determined by Dr. R. Norman Jones of Harvard University using a Bausch and Lomb medium quartz spectrograph in conjunction with a Hilger Spekker photometer and a hydrogen discharge tube.

Summary

Echinocystic acid on vacuum distillation loses a molecule of carbon dioxide and one of water to give norechinocystadienol. The ultraviolet absorption spectrum shows that this compound contains two conjugated double bonds in different rings. These facts are in accordance with the proposed structure of echinocystic acid.

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